3-30-2010

Follow Up Nucleate Boiling On-Flight Experiment

Andrew Fassmann
Utah State University

Follow Up Nucleate Boiling On-flight Experiment

Andrew Fassmann

USU's Get Away Special Team

- The team started with NASA's Get Away Special (GAS) Program.
- After discontinuation of GAS Program, we have still continued looking for options in microgravity research.
- Currently working with NASA's Reduced Gravity Office.
- Also working with Space Adventures to use International Space Station as a resource.

Nucleate Boiling Overview

- Nucleate Boiling is one of 4 types of boiling known for its high heat transfer rate.
- The GAS Team's first experiment was flown on the Shuttle in 2001.
- The first boiling experiment resulted in mostly qualitative and visual data.

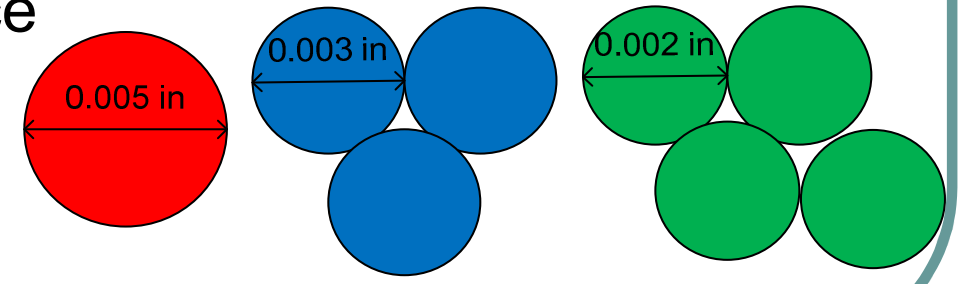
Experiment Objectives

- Observe nucleate boiling with varying power input and surface geometry in microgravity.
- Determine effects of varying power and surface geometry on nucleate boiling.
- Develop analytical models for bubble growth on and departure from heating element.

Experiment Overview

- Three heating elements (platinum wire) run through three separate boiling cells.
- Specified current (based on resistance of wire) is run through wire.
- Data is recorded.
- About Five values of power and three surface geometries will be cycled to observe and vary different heat flux values.

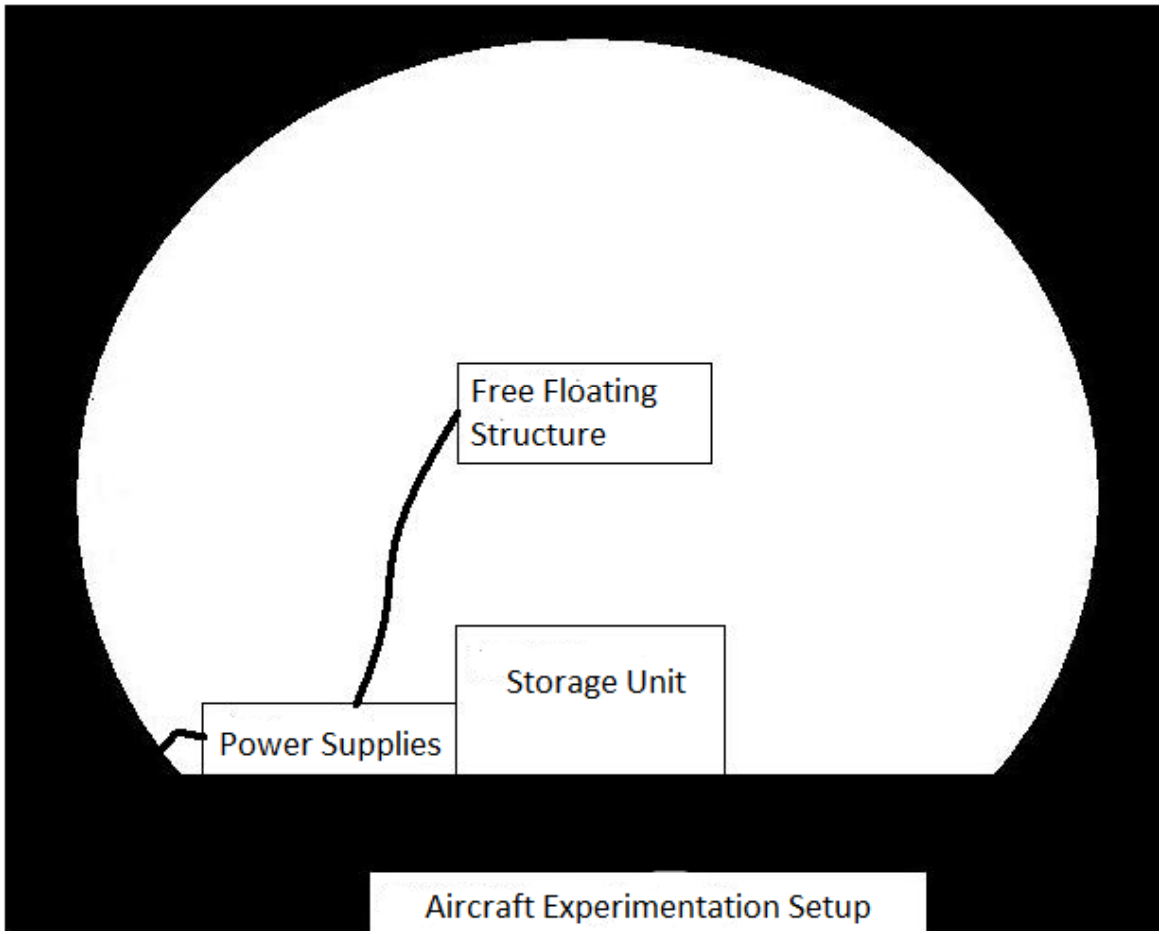
Power (W)	Single Current (A)	3 Wire Current (A)	4 Wire Current (A)
1.5	4.23	4.40	3.39
2	4.89	5.08	3.91
2.5	5.47	5.68	4.37
3	5.99	6.22	4.79
3.5	6.47	6.72	5.17
4	6.91	7.19	5.53
4.5	7.33	7.62	5.87
5	7.73	8.03	6.18



Measurements

- Actual Power through Heating Element
  - Measure Voltage Across Known Resistor
- Temperature of the Heating Element
  - Measure Voltage Across the Wire
  - Solve for Resistance Change in Wire
  - Use Resistance Change to Find Temperature of Platinum
- Radial Temperature Distribution
  - 4 Thermocouples Measure Radial Temperature
- Gravity vs. “Bumping” Forces
  - Tri-axis Accelerometer Measurements
- Visual Data
  - 2 HD Video Cameras per Cell (6 Total)

Design Overview

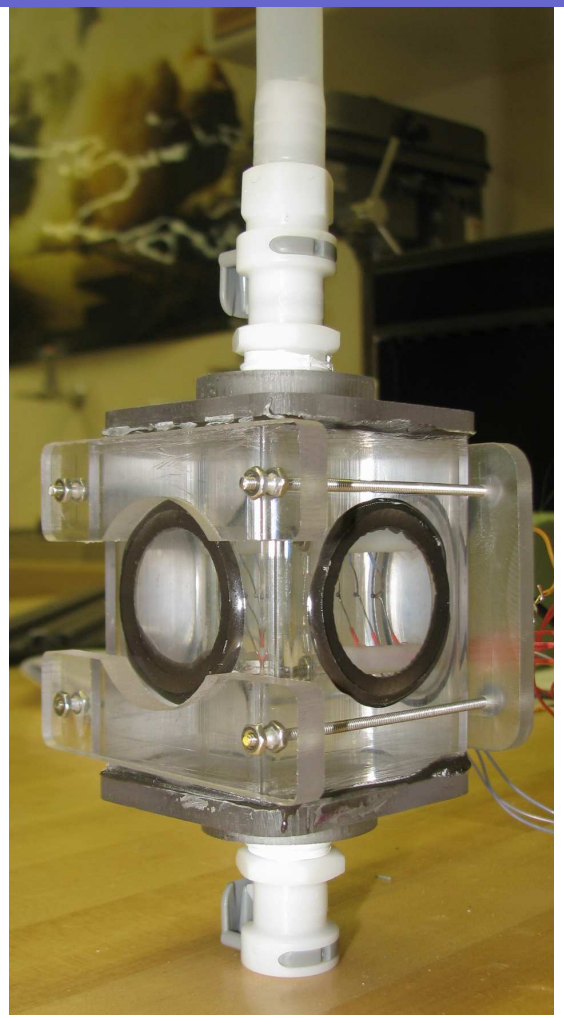


Free Floating Structure

- DAQ System
  - Isolated
  - Power for Lighting (2 x D Cells)
- Boiling Cells
  - Water Tight
  - Mounted cameras and cells in one structure
  - Anderson Power Pole connectors for thermocouples and voltages

Boiling Chamber

- 6.5 fluid ounces
- O-ring Gasket with Clamping System
- Two Windows at 90^{o} Relative to Each Other
- Quick Disconnect Valves for Easy Filling and Draining



Cameras

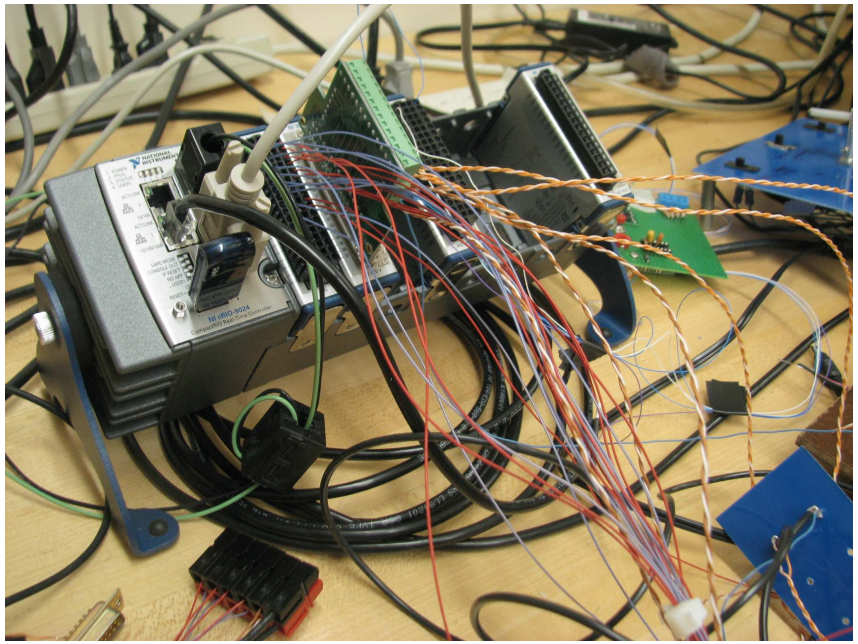
- Six Cameras under $1000
- 1 cm Field of View
- Pixel Resolution of 1 pixel to 0.01 mm
- Kodak Zi8 - $150
  - 1080p Resolution
  - Slightly > 1 cm field of view with 4x magnification

Lighting

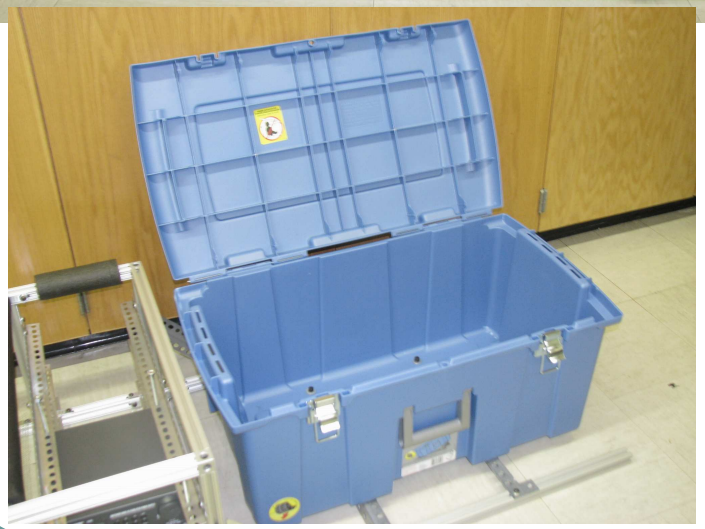
- Measureable Bubbles
  - Reduce Glare
  - Soft Rear Box Lighting
  - Harsh Lighting from Underneath Cell

Data Acquisition

- Controller:
  - 800 MHz Processor
  - Serial/USB Interfacing
- Analog Input Module
  - Differential or Referenced Measurements.
- Thermocouple Module
  - 16 Channels @ 75 Samples/sec per channel
- Analog Output Module
- Digital I/O Module



Ground Structure



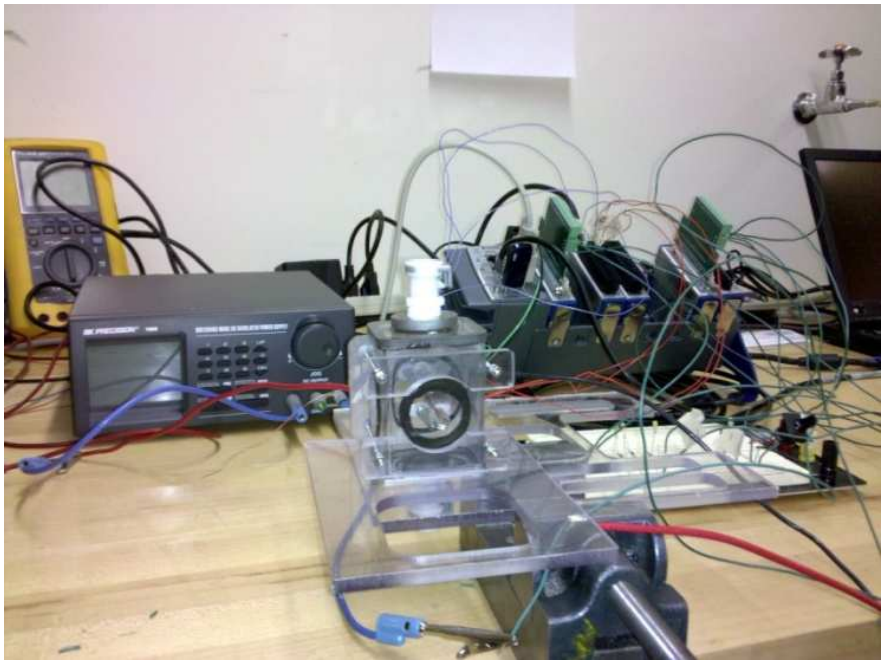
- 80/20 Aluminum Framing
- Mounting for Power Supplies and Umbilical
- Storage Unit for up to 30 Boiling Cells

Power Supplies

- BK Precision Power Supply
  - +/- 20 Volts
  - 10 Amps
  - Controllable over serial port with LABView.
  - Ability to control multiple supplies at once.

Summary

- The main role of the experiment is to understand boiling in space and on earth.
- Most of the major design and testing is completed, but we are still working.



Questions?